Chromospheric activity of the double-lined spectroscopic binary BF Lyn

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Abstract.

We present simultaneous spectroscopic observations taken during four observing runs (1996 to 1999) of Hα, Hβ, Hϵ, Ca II H & K, and Ca II IRT lines of the chromospherically active binary BF Lyn. Both components have strong emission in the Hϵ, Ca II H & K and Ca II IRT lines and a strong filling-in of the Hα and Hβ lines have been observed after the application of the spectral subtraction technique. We have found that the hot component (K2 V) is always the most active of the system. The different activity indicators of the hot and cool components show anticorrelated variations with the orbital phase.

1. Introduction

BF Lyn (HD 80715) is a double-lined spectroscopic binary with spectral types K2V/[dK] and both components have variable Hα emission and strong Ca II infrared triplet emission noted by Barden and Nations (1985). Strassmeier et al. (1989) observed strong Ca II H & K and Hϵ emissions from both components. The orbital period is 3.80406 days (Barden and Nations, 1985) and Strassmeier et al. (1989) from photometric observations found that BF Lyn is a synchronized binary with a circular revolution for a long time. Montes et al. (1995) also found strong emission in the Ca II H & K lines from both components with very similar intensities and the Hϵ line in emission too.

In this paper we present simultaneous spectroscopic observations of Hα, Hβ, Hϵ, Ca II H & K, and Ca II IRT lines of this chromospherically active binary.

2. Observations

Spectroscopic observations in several optical chromospheric activity indicators of BF Lyn and some inactive stars of similar spectral type and luminosity class have been obtained during four observing runs.
1) Two runs were carried out with the 2.56 m Nordic Optical Telescope (NOT) at the Observatorio del Roque de Los Muchachos (La Palma, Spain) in March 1996

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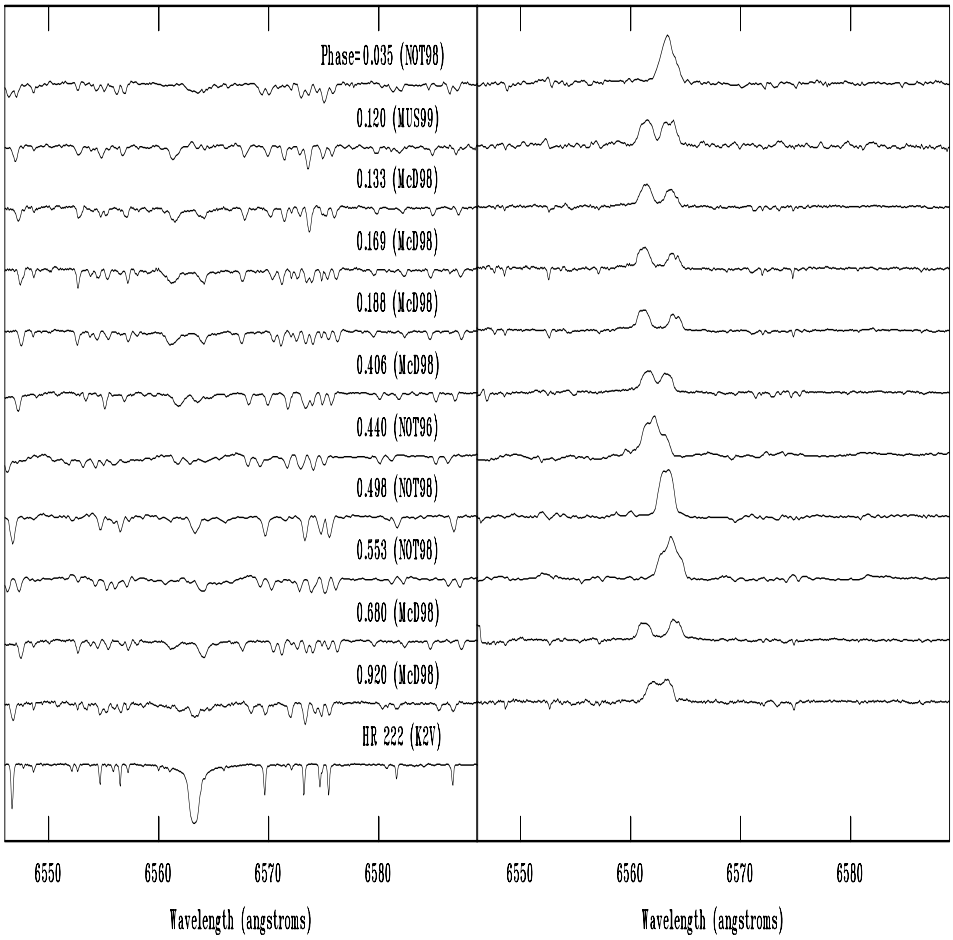

Figure 1. The left panel shows the observed spectra of BF Lyn and the HR 222 (K2V) reference star, in the Hα line region. The right panel shows the subtracted spectra of BF Lyn.

and April 1998, using the SOFIN echelle spectrograph covering from 3632 Å to 10800 Å (resolution from $\Delta\lambda$ 0.15 to 0.60 Å), with a 1152×770 pixels EEV P88200 CCD as detector.
2) One observing run was obtained using the 2.1 m telescope at McDonald Observatory (USA) in January 1998 using the Sandiford Cassegrain Echelle Spectrograph covering from 6382 Å to 8700 Å (resolution from $\Delta\lambda$ 0.13 to 0.20 Å), and with a 1200×400 pixels Reticon CCD as detector.
3) The last run was carried out with the 2.5 m INT at the Observatorio del Roque de Los Muchachos (La Palma, Spain) in January 1999 using the Multi-Site Continuous Spectroscopy (MUSICOS), covering from 3950 Å to 9890 Å (resolution from $\Delta\lambda$ 0.15 to 0.40 Å), with a 2148×2148 pixels SITe1 CCD as detector.

In the four runs we have obtained 11 spectra of BF Lyn in different orbital phases. Stellar parameters of BF Lyn have been adopted from Strassmeier et al.

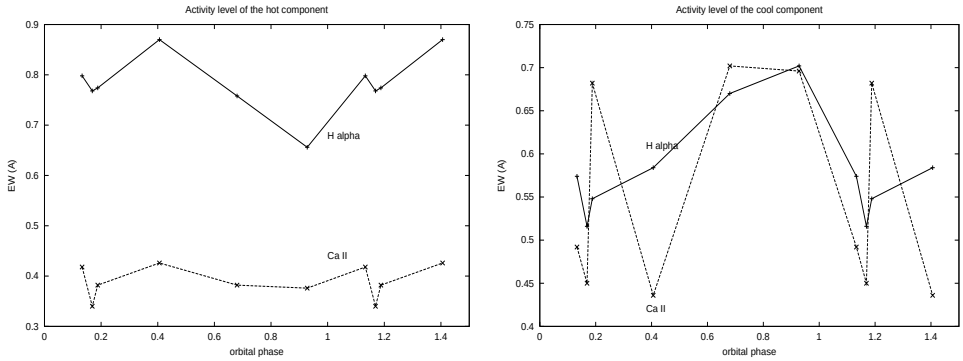

Figure 2. Hα and Ca II IRT λ8542 EW of the hot (left panel) and cool (right panel) components for the McD98 run versus the orbital phase.

(1993), except for T_{conj} taken from Barden & Nations (1985). The spectra have been extracted using the standard reduction procedure in the IRAF package (bias subtraction, flat-field division and optimal extraction of the spectra). The wavelength calibration was obtained by taking spectra for a Th-Ar lamp. Finally the spectra have been normalized by a polynomial fit to the observed continuum. The chromospheric contribution in the activity indicators has been determined using the spectral subtraction technique.

3. The Hα line

We have taken several spectra of BF Lyn in the Hα line region in four different epochs and at different orbital phases. In all the spectra we can see the Hα line in absorption from both components. The spectral subtraction reveals that both stars have an excess Hα emission. The line profiles are displayed in Fig. 1, for each observation we plot the observed spectrum (left panel), and the subtracted one (right panel). The excess Hα emission equivalent width (EW) is measured in the subtracted spectrum and corrected for the contribution of the components to the total continuum, in the case of BF Lyn we assume the same contribution for both stars. At some orbital phases, near to the conjunction, is not possible to separate the contribution of both components. The excess Hα emission of BF Lyn shows variations with the orbital phase for both components, the hot star is the most active in Hα. In Fig 2 we have plotted for the McD 98 observing run the Hα EW versus the orbital phase for the hot and cool components, respectively. The highest Hα EW for the hot component has been reached at about 0.4 orbital phase and the lowest value is placed at about 0.9 orbital phase, whereas the cool component shows the highest Hα EW at near 0.9 orbital phase and the lowest value between 0.2 and 0.4 orbital phases. The variations of Hα EW for both components are anticorrelated and the maximum of active areas are found on the faced hemispheres. The same behaviour is also found in Ca II IRT. The excess Hα EW emission also shows seasonal variations, for instance,

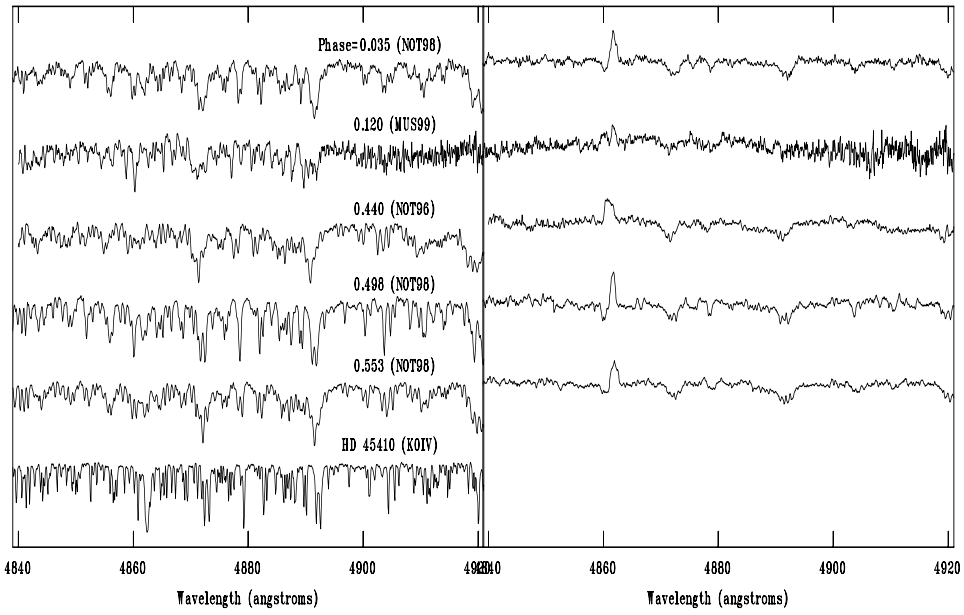

Figure 3. As in Fig. 1 for the Hβ line region.

the values of MUSICOS 99 observing run are very different, specially for the cool component, from McD 98 values at very near orbital phase.

4. The Hβ line

Five spectra in the Hβ region are available in three different epochs and at different orbital phases. In all the spectra the Hβ line appears in absorption from both components, the application of the spectral subtraction technique reveals a clear excess Hβ emission from both stars. The line profiles are displayed in Fig. 3. We have determined the excess Hβ emission EW in the subtracted spectra, the ratio of excess emission EW, and the $\frac{E_{H\alpha}}{E_{H\beta}}$ relation:

$$\frac{E_{H\alpha}}{E_{H\beta}} = \frac{EW_{sub}(H\alpha)}{EW_{sub}(H\beta)} \cdot 0.2444 \cdot 2.512^{(B-R)} \qquad (1)$$

given by Hall & Ramsey (1992) as a diagnostic for discriminating between the presence of plages and prominences in the stellar surface. The low ratio that we have found in BF Lyn do not allow us to discriminate between both structures.

5. The Ca II IRT lines

The Ca II infrared triplet (IRT) λ8498, λ8542, and λ8662 lines are other important chromospheric activity indicators. We have taken several spectra of BF Lyn in the Ca II IRT lines region in three different epochs and at different orbital phases, the three Ca II IRT lines are only included in MUSICOS 99 observing

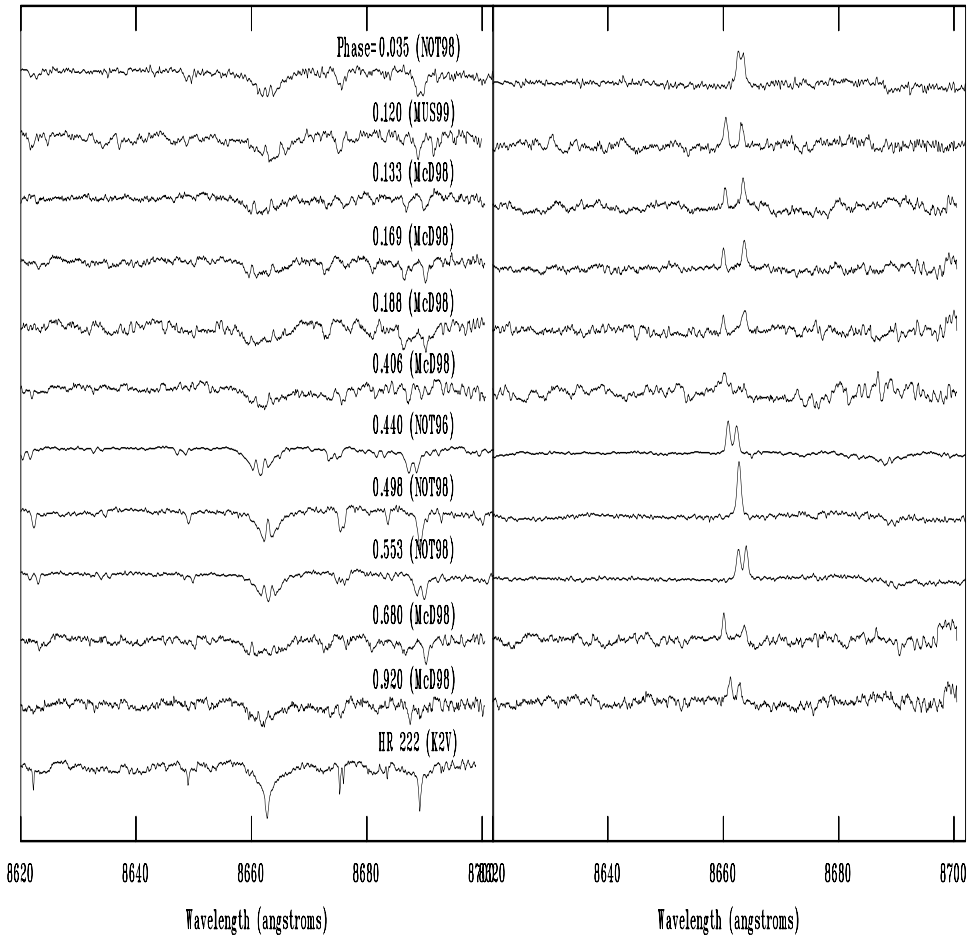

Figure 4. As in Fig. 1 for the Ca II IRT λ8662 line region.

run. In all the spectra we can see the Ca II IRT lines in emission from both components (Fig. 4). As in the case of Hα line the Ca II IRT emission shows variations with the orbital phase for both components. In Fig. 2 we have plotted, for the McD 98 observing run, the Ca II λ8542 EW versus the orbital phase for the hot and cool component, respectively. The variations of Ca II emission EW for both components are anticorrelated and they show the same behaviour found in the excess Hα emission EW.

6. The Ca II H & K and Hϵ lines

We have taken four spectra in the Ca II H & K lines region during the NOT (96 & 98) observing runs and other spectrum of BF Lyn was taken in 1993 with the 2.2 m telescope at the German Spanish Astronomical Observatory (CAHA) (Montes et al., 1995). These spectra (Fig. 5) exhibit clear and strong Ca II H & K and Hϵ emission lines from both components, in the case of CAHA 93 run the Hϵ emission line from the hot component is overlapped with the Ca II H

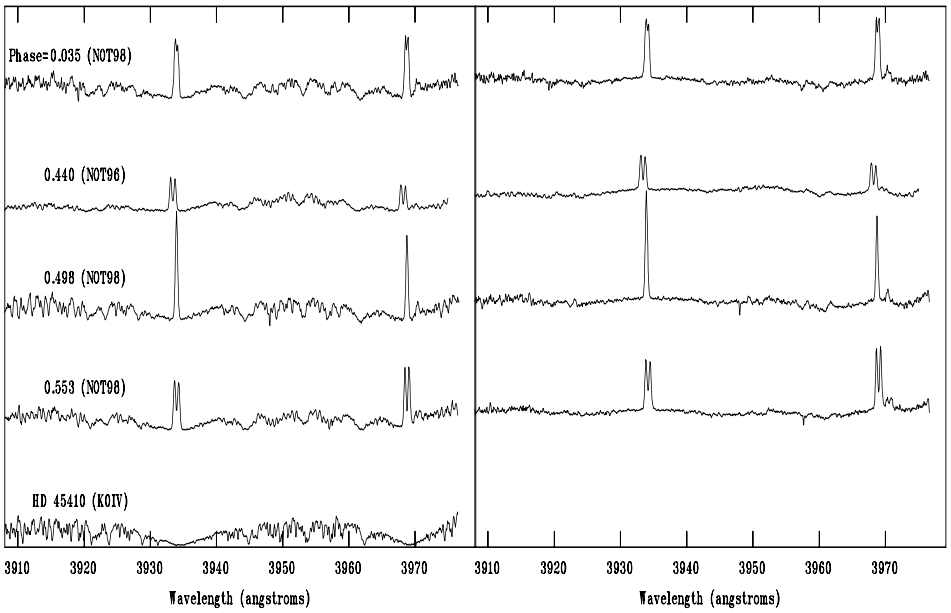

Figure 5. As in Fig. 1 for the Ca II H & K line region.

emission of the cool component. The excess Ca II H & K and Hϵ emissions change with the orbital phase during the NOT 98 run in the same way as the corresponding excess Ca II λ8542 and Hα emissions. The excess Ca II H & K EW emissions also show seasonal variations, for instance, the values of CAHA 93 observing run are lower than NOT 96 & 98.

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